XLIV. *New Experiments upon the* Leyden *Phial, reſpecting the Termination of Conductors.* *By* Benjamin Wilſon, *Eſq. F. R. S.*

Read July 9, 1778.

IN the LXIVth volume of the Philoſophical Tranſactions there is a paper of Mr. HENLY's upon the ſubject of conductors, wherein are contained ſeveral experiments, intended to ſhew that pointed terminations are preferable to ſpherical ones for ſecuring buildings, &c. from accidents by lightning.

Upon thoſe experiments I made ſome obſervations, and particularly upon the fifth, where a point and ball were placed at the ſame diſtance from a ſphere of copper, ſo as to make part of the circuit in the Leyden experiment[a]. In the deſcription of that experiment I objected to the two chains employed therein, becauſe the metallic communication was, by that method, conſiderably interrupted, on account of a want of contact between the ſeveral links compoſing the chains. I did not then repeat the experiment becauſe the particular circumſtances attending the Leyden phial appeared, in my

(a) Farther Obſervations upon Lightning, by B. WILSON, publiſhed in Phil. Tranſ. for the year 1774.

judge-

judgement, very unlike what happens in nature; and therefore I contented myſelf with pointing out the ſeveral circumſtances in which they differed; and in obſerving that, according to Mr. HENLY's account, the point did not protect the rounded end from being ſtruck, which it ought to have done, if Dr. FRANKLIN's philoſophy was well-founded.

Since that time an occaſion has offered which made it neceſſary to try this particular experiment. The occaſion alluded to aroſe from a late inveſtigation of Mr. NAIRNE's experiments by Dr. MUSGRAVE, who was deſirous of having that experiment repeated; becauſe (as it ſtood in Mr. HENLY's account) it ſeemed to contradict a conſiderable part of the doctor's reaſoning.

Not being furniſhed with an apparatus to make the experiment, I requeſted the favour of Mr. CAVALLO to aſſiſt me with his; and though it was not ſo compleat for the purpoſe as could be wiſhed, yet it anſwered ſufficiently well to ſhew, that an attention to the circumſtance of a perfect communication in this experiment was very material to diſcover the truth; and that the want of it had, probably, occaſioned the ball being ſtruck in preference to the point, as related by Mr. HENLY: for upon employing a wire inſtead of the chains, the point was ſtruck at more than *three times* the diſtance of the ball.

Seeing

Seeing ſo great a difference between the two experiments, I ordered ſuch an apparatus to be made as I thought would be the leaſt exceptionable for the purpoſes of determining the fact upon which theſe different appearances ſeemed to depend; namely, a perfect and an imperfect circuit of communication with the Leyden phial.

In the contriving of this inſtrument it appeared material, in order to have it anſwer the ſame end as Mr. LANE's electrometer, that the ſeveral experiments to be tried with it might be compared with each other in a more accurate manner.

The circuit of communication was divided into two parts. A bent rod of braſs, with a ball of the ſame metal, three quarters of an inch in diameter, ſcrewed on to the upper extremity of it, and a copper ball, five inches in diameter, ſcrewed on to the lower end, formed one of the parts. This part was ſupported by a ſtand of wood that had a cap of braſs at the top, into which the braſs rod was occaſionally ſcrewed.

The other part of the circuit conſiſted of a braſs rod alſo, one end of which branched out in the form of a fork with two prongs, that pointed towards the center of the copper ball; and thoſe prongs were ſo conſtructed,

that either of them could be made longer or ſhorter, juſt as the experiment required. On the end of one of the prongs was fixed a ball of braſs, three quarters of an inch in diameter, and on the other a ſharp ſteel point or needle. The ſhoulder of this fork ſcrewed into a ſmall plate of iron that was fixed on the inſide of a wooden veſſel, which contained the greateſt part of a cylindrical glaſs jar twelve inches and three quarters high, and about four inches in diameter. This glaſs was rather thick than otherwiſe, and the coating of it (which was tin-foil) meaſured nearly 144 ſquare inches on each ſurface. Beſides this coating, part of the inſide of the wooden veſſel was coated alſo with tin-foil, for the purpoſe of making a ſecure communication between the iron plate and the outward coating of the jar. Within the jar itſelf was fitted a cylinder of wood, that was covered with tin-foil alſo, to make a communication between the inſide coating of the glaſs and a braſs rod that was fixed upright in the center of the wooden cylinder. This upright rod having a ball of braſs at the end, three quarters of an inch in diameter, was bent towards the firſt part of the circuit: ſo that the two balls A and B in plate XVIII. fig. 2. being upon a level, looked towards each other, but were placed

placed from time to time at different diſtances, as occaſion required, and thus anſwered the purpoſe of an electrometer.

Whilſt this inſtrument was making, Dr. LIND propoſed to Mr. CAVALLO and myſelf, that we ſhould ſee ſome experiments at his houſe which he had made in conſequence of thoſe we had before tried at Mr. CAVALLO's.

The apparatus he made uſe of was but ſmall (ſee fig. 1.); for the phial contained very little more than a pint, and the coating on its outward ſurface meaſured no more than thirty-nine ſquare inches.

The reſults of the ſeveral experiments we made are contained in the firſt of the following tables, from which it will appear, that in twenty-three experiments there was not any *one inſtance* where the ball was ſtruck at a greater diſtance than the point, nor even at the ſame diſtance. It is remarkable, that in two or three experiments where the point was farther off than the ball, both the point and the ball were ſtruck at the ſame time; which ſhews, that the influence of the point, although placed at a greater diſtance, was equal to the influence of the ſpherical termination placed conſiderably nearer.

When the forked inſtrument and electrometer were finiſhed, it was found, that a ſuperior force was neceſ-

ſary to charge the jar belonging to it (on account of its thickneſs) than what we had employed in our firſt trials.

Upon an application to Dr. HIGGINS he favoured me with the uſe of his machine; the cylinder of which, when excited with the aſſiſtance of his amalgama, acted ſo powerfully, that it charged the jar, accompanying the new inſtrument, very readily.

We began the experiments where the electrometer was ſtruck at the greateſt diſtance, and then adjuſted the diſtances of the ball and point from the copper ball accordingly; ſo that if the point was ſtruck (when they were adjuſted) the moving of the ball $\frac{1}{32}$d part of an inch would occaſion the ball to be ſtruck in preference to the point, and *vice verſâ*. Afterwards we leſſened the ſtriking diſtance of the electrometer in every experiment till we attained the leaſt diſtance.

Upon reverſing part of the apparatus, as in fig. 3. all thoſe experiments were repeated again; the copper ball being put neareſt to the glaſs in the place of the forked part, and the forked part in the place of the copper ball. This ſet of experiments being compleated, we made others, where the ball only was oppoſed; and after them, where the point only was oppoſed to the copper ball.

Having

Having gone through all theſe experiments as they are ſet down in the ſecond table, we then repeated the experiment with the chain, after Mr. HENLY's manner. The reſult of which, and with the apparatus reverſed, will appear in the third table.

The chain we employed upon this occaſion was of iron and very ruſty, no other being then at hand.

To avoid every objection it was reſolved upon, that all the experiments we had made at Dr. HIGGINS's ſhould be repeated, but with the two chains inſtead of the forked apparatus.

On the 23d of June, by the favour of Mr. PARTINGTON (Dr. HIGGINS having diſpoſed of his machine at that time) we went through the whole of the experiments thus circumſtanced. The chains employed were braſs, and a glaſs ſtand ſupported the ball and point. Mr. PARTINGTON's cylinder meaſured about thirteen inches in diameter: this glaſs, with the aſſiſtance of Dr. HIGGINS's amalgama, acted powerfully. All theſe experiments are contained in the fourth table.

Before this paper is concluded, it is neceſſary to caution thoſe who may be diſpoſed to repeat the experiments mentioned in the ſeveral preceding tables, that a ſtrict attention be had to every the leaſt circumſtance re-

lative to the making of the experiments; it being ſo difficult to preſerve the intended diſtances between the reſpective parts of an apparatus not perfectly executed (as is frequently the caſe with all new inſtruments) that we could not ſucceed in adjuſting the diſtances of the electrometer, ſo as to be exactly in an arithmetical progreſſion.

June 23, 1778. B. WILSON.

TABLE

TABLE I. FIG. I.

Experiments made at Dr. LIND's, June 18, 1778, with the Leyden phial.

	Point and ball oppoſite the Leyden phial.			Ball only.	Point only.	Appar. reverſ.	Ball only.	Point only.
I.	Electrometer	68	– –	65	65	64		
	Ball –	18	Both ſtruck twice	59	–	18	Both ſtruck at	
	Point –	24	at the ſame time.	–	112	24	the ſame time.	
II.	Electrometer	64	– –	54	54	–	54	54
	Ball –	18	Both ſtruck twice	56	–	–	51	
	Point –	24	at the ſame time.	–	95	–	– –	66
III.	Electrometer	40	– –	–	–	40		
	all –	18	– –	–	–	18		
	Point –	25	– –	–	–	24		
(b) IV.	Electrometer	28	– –	28	28	–	28	28
	Ball –	34	ſtruck alternately.	26	–	–	23	
	Point –	73		–	68	–	– –	44
V.	Electrometer	24						
	Ball –	44						
	Point –	60						
VI.	Electrometer	22	– –	–	–	22		
	Ball –	18	– –	–	–	18		
	Point –	46	– –	–	–	26		
VII.	Electrometer	18	– –	–	–	18		
	Ball –	18	– –	–	–	18		
	Point –	48	– –	–	–	36		
VIII.	Electrometer	16	– –	–	–	16		
	Ball –	20	– –	–	–	15		
	Point –	56	– –	–	–	31		

N. B. Eighty of thoſe parts make one inch.

The number oppoſite the word electrometer denotes the diſtance between the balls which conſtituted the electrometer; and the numbers oppoſite to the words *ball* and *point* ſhew the ultimate diſtance at which they were reſpectively ſtruck.

(b) The point and ball in this experiment were not directed immediately towards the outſide coating of the jar, but towards the broad ſurface of a common tea canniſter, the oppoſite outſide of which was in contact with the coating of the jar.

JAMES LIND. TIBERIUS CAVALLO. B. WILSON.

TABLE II. FIG. II.

Experiments made at Dr. HIGGINS's, June 19, 1778, with the Leyden phial and Forked apparatus.

The meaſures expreſſed in the following tables were taken from a ſcale containing 32 parts in one inch.

Ball and point oppoſite the Leyden phial.		Ball only.	Point only.	Apparatus reverſed.		Ball only.	Point only.
I.	Electrometer 32	32	32	32	– – –	32	32
	Ball – 34	48	–	34	– – –	36	–
	Point – 45	–	88	42	– – –	–	42
II.	Electrometer 28	28	28	28	– – –	28	28
	Ball – 30	43	–	36	– – –	33	–
	Point – 38	–	78	42	– – –	–	39
III.	Electrometer 25	26	26	25	– – –	26	26
	Ball – 28	36	–	31	– – –	32	–
	Point – 37	–	67	32	– – –	–	33
IV.	Electrometer 20	20	20	20	This exp. being repeated at intervals, other exp. intervening, gave the following reſults: 20 20 / 28 30 / 27 29	20	20
	Ball – 28	29	–	29		25	–
	Point – 51	–	64	28		–	24
V.	Electrometer 16	16	16	16	– – –	16	16
	Ball – 22	20	–	22	– – –	23	–
	Point – 44	–	47	24	– – –	–	26
VI.	Electrometer 13	13	13	13	– – –	13	13
	Ball – 21	14	–	16	– – –	18	–
	Point – 38	–	36	22	– – –	–	22
VII.	Electrometer 10	10	10	10	– – –	10	10
	Ball – 12	10	–	13	– – –	12	–
	Point – 18	–	25	20	– – –	–	20

TABLE

TABLE III.

Experiments with the chain after Mr. HENLY's manner.

Point and ball oppoſite the Leyden phial.		Apparatus reverſed.		
Electrometer –	21	23	repeated at different times,	23
Ball – –	26	28		26
Point – –	24	26		30

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TABLE IV. FIG. III.

The experiments of the ſecond and third table repeated at Mr. PARTINGTON'S, June 23, 1778, a braſs chain being uſed inſtead of the Forked apparatus.

	Ball and point oppoſite the Leyden phial.		Ball only.	Point only.	Apparatus reverſed.			Ball only.	Point only.
I.	Electrometer	32	32	32	32	–	–	32	32
	Ball –	40	39	–	30	–	–	29	–
	Point –	76	–	71	38	–	–	–	39
II.	Electrometer	28	28	28	28	–	–	28	28
	Ball –	33	36	–	29	–	–	28	–
	Point –	72	–	66	37	–	–	–	38
III.	Electrometer	25	26	26	25	repeated	25	26	26
	Ball –	33	33	–	28		28	27	–
	Point –	46	–	64	35		37	–	37
IV.	Electrometer	20	20	20	20	–	–	20	20
	Ball –	21	23	–	24	–	–	24	–
	Point –	50	–	60	26	–	–	–	27
V.	Electrometer	16	16	16	16	–	–	16	16
	Ball –	21	15	–	19	alternately		19	–
	Point –	55	–	53	21			–	24
VI.	Electrometer	13	13	13	13	–	–	13	13
	Ball –	16	11	–	14	–	–	15	–
	Point –	44	–	42	19	–	–	–	22
VII.	Electrometer	10	10	10	10	–	–	10	10
	Ball –	11	9	–	11	alternately		12	–
	Point –	38	–	37	19			–	19

Becauſe the electrometer in the experiments contained in the third table made at Dr. HIGGINS'S with a ruſty

iron chain ſtood at 21 and 23, we repeated the experiment at Mr. PARTINGTON's with a braſs chain, and the reſult was as follows:

Ball and point oppoſite the Leyden phial.	Apparatus reverſed.
Electrometer – 21	23
Ball – – 24	25
Point – – 64	30

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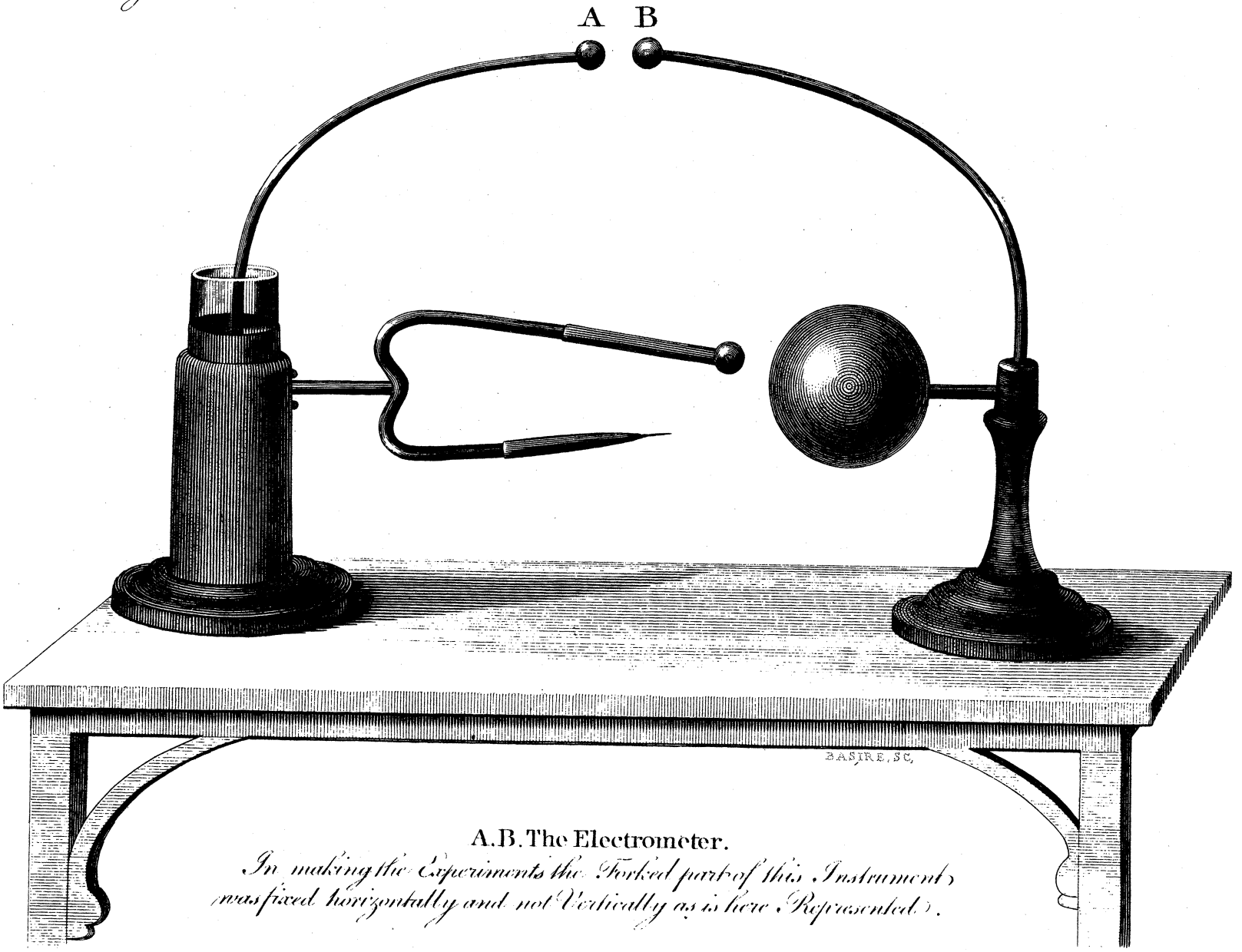
P. S. Having ſeen a method uſed by Mr. CAVALLO to repair broken Leyden phials, ſo as to render them again uſeful for experiments, I am glad of this opportunity to make it known, as it may be very acceptable to electricians. The method is as follows. When a coated phial is cracked, either by a ſpontaneous diſcharge or by any other accident, Mr. CAVALLO removes the outſide coating from the fractured part, and then makes it moderately hot, by holding it to the flame of a candle; and whilſt it remains hot, he applies burning ſealing wax to the part, ſo as to cover the fracture entirely; taking care that the thickneſs of the wax is rather more than the thickneſs of the glaſs. Laſtly, he covers all the ſealing wax, and alſo

part of the ſurface of the glaſs beyond it, with a compoſition made with four parts of bees wax, one of reſin, one of turpentine, and a very little oil of olives; which compoſition he ſpreads upon a piece of oiled ſilk, and applies it in the manner of a plaiſter. With this method I have ſeen ſeveral phials ſo effectually repaired, that, though after being frequently charged, they were at laſt broken by a ſpontaneous diſcharge, yet the fracture was in a different part of the glaſs.

Leyden Phial

Fig 2



A.B. The Electrometer.

In making the Experiments the Forked part of this Instrument was fixed horizontally and not Vertically as is here Represented.

Leyden Phial

Fig. 3.

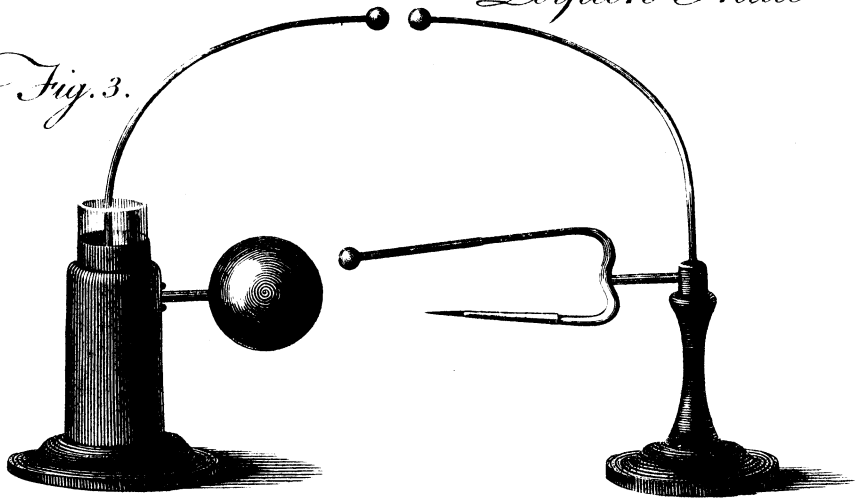


Fig. 1.